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Doctoral thesis

Title: A mathematical study of symmetric structures inspired by soft matter systems: the QTZ-QZD family of triply-periodic minimal surfaces and doubly-periodic knitted fabrics¹.

Advisor: Dr. Elisabetta A. Matsumoto, Assistant Professor, The School of Physics, Georgia Tech, GA-30332, USA.

Education

PhD in Physics. Georgia Tech, Atlanta, GA-30332, USA	August 2015 - Present
Masters in Mathematics. Georgia Tech, Atlanta, GA-30332, USA	August 2015 - Present
Integrated Masters of Science in Physics. UM-DAE Centre for Excellence in Basic Sciences, Mumbai, Maharashtra, India.	August 2009 - July 2014

Professional Experience

Graduate Research Assistant, The Department of Astronomy & Astrophysics, Tata Institute of Fundamental Research, Mumbai, Maharashtra, India.	August 2014 - July 2015
Graduate Research Assistant (GRA), The School of Physics, Georgia Tech, GA-30332, USA	Spring 2017, Summer 2019 & Fall 2020 semesters.
Graduate Teaching Assistant (GTA), The School of Physics, Georgia Tech, GA-30332, USA	August 2015 - July 2020

Publications

- [1] Shashank G. Markande, Elisabetta A. Matsumoto. “A knot-theoretic study of two-periodic knitted fabrics”. This manuscript that is currently under preparation, will be submitted to *The Journal of Experimental Mathematics* (2020).
- [2] Shashank G. Markande, Elisabetta A. Matsumoto. “Knotty knits are tangles on tori”, *Proceedings of Bridges 2020: Mathematics, Music, Art, Architecture, Culture in press* (2020), and available at <http://archive.bridgesmathart.org/2020/bridges2020-103.html>.
- [3] Shashank G. Markande, Matthias Saba, Gerd E. Shröder-Turk, Elisabetta A. Matsumoto. “The QTZ-QZD Surfaces: A chiral family of triply-periodic minimal surfaces derived from the quartz network”, *Proceedings of Royal Society A*, under review (2018), and available at <https://arxiv.org/abs/1805.07034>.

¹pending completion.

Scholarships & Awards

2019	STAMI Graduate Fellowship ^a awarded by Science & Technology of Advance Materials & Interfaces (STAMI), Georgia Tech for excellence in research.
2019	The Scientific Travel Award (STAP) ^b , Science & Technology of Advance Materials & Interfaces (STAMI), Georgia Tech.
2017-20	Amelio Endowment Travel Award, The School of Physics, Georgia Tech.
2017-20	Graduate Conference Fund ^c , Student Government Association (SGA), Georgia Tech.
2017-20	Doctoral Student Travel Supplement, College of Natural Sciences, Georgia Tech.
2011	Certificate of Appreciation, National Board of Higher Mathematics (NBHM), Government of India for excelling in the Madhava Mathematics Competition (MMC). ^d
2009-14	DST-INSPIRE scholar ^e – a scholarship awarded as a student stipend to pursue the Integrated Masters of Science program.

Oral & Poster presentations

- *A study of triply periodic minimal surfaces & sets of two-periodic strings inspired by periodic structures in soft matter systems.* UPenn soft matter seminar series, Department of Physics and Astronomy, Philadelphia, PA, November 2020.
- *Minimal surfaces & knots.* Seminar, School of Science and Technology, Physics, Georgia Gwinnett College, Lawrenceville, 30043-GA, October 2020.
- *A study of symmetric structures in soft materials: three-periodic surfaces & sets of two-periodic strings.* Seminar, Plots and Scotch – The CMU Biophysics Seminar Series, Biophysics MCS, CMU, Pittsburgh, PA, August 2020.
- *A study of knits as textile knots & links: knots & links derived from stitch patterns of knitted fabrics.* Poster presentation, The 12th Southeast Soft Matter Virtual Symposium, Georgia Tech & Emory University, Atlanta, GA, August 2020.
- *A study of two-periodic knitted fabrics using knots & tangles.* APS march meeting, March 2020.
- *A topological perspective on knitted fabrics.* APS march meeting, Boston, MA, USA, March 2019.
- *A study of knots & links derived from doubly periodic knitted fabric patterns.* Geometry Topology Student Seminar, the School of Mathematics, Georgia Tech, Atlanta, GA, USA, 6 November 2019.
- *The QTZ-QZD surfaces: A family of chiral triply-periodic minimal surfaces derived from the quartz network.* Poster presentation, Summer School on Soft Solids & Complex Fluids at UMass, Amherst, MA, USA, May 2018.
- *The QTZ-QZD surfaces: A family of chiral triply-periodic minimal surfaces derived from the quartz network.* Poster presentation, The 11th Southeast meeting on Soft Materials, Emory University, Atlanta, GA, USA, May 2018.
- *The QTZ-QZD family of surfaces: a triply-periodic family of chiral minimal surfaces.* Poster presentation, A Symposium on Soft Matter Frontiers, Georgia Tech, Atlanta, GA, April 2018.
- *The QTZ-QZD surfaces: A triply-periodic family of chiral minimal surfaces from space group symmetries.* Oral presentation, Southeastern Undergraduate Mathematics Workshop, School of Mathematics, Georgia Tech, Atlanta, GA, USA, August 2017.

- *The QTZ-QZD surfaces: A family of chiral triply-periodic minimal surfaces derived from the quartz network.* Soundbite, The 10th Southeast meeting on Soft Materials, SMI, STAMI, Georgia Tech, Atlanta, GA, USA, May 2017.
- *The QTZ-QZD surfaces: A triply-periodic family of chiral minimal surfaces from space group symmetries.* Poster presentation, Soft Matter Lunch and Posters, SMI, STAMI, Georgia Tech, Atlanta, GA, USA, April 2017.
- *A chiral minimal surface family from space group symmetries.* APS March meeting, New Orleans, LA, USA, March 2017.
- *The QTZ-QZD surfaces: A family of chiral triply-periodic minimal surfaces derived from the quartz network.* Oral presentation, Soft Matter Research Chat, School of Physics, Georgia Tech, Atlanta, GA, USA, 2017.

Conferences & Workshop Activity/Participation

- [1] The 12th Southeast Soft Matter Virtual Symposium, Georgia Tech & Emory University, Atlanta, GA, August 2020.
- [2] APS March meeting, March 2020.²
- [3] Geometry Topology Student Seminar, the School of Mathematics, Georgia Tech, Atlanta, GA, USA, 2019.
- [4] Computational Textiles Working Group, The Institute for Computational and Experimental Research in Mathematics (ICERM), Providence, RI, September 2019.
- [5] Short courses on High performance GPU computing on a web browser using WebGL, Introduction to Uncertainty Quantification, Conference of Computational Interdisciplinary Science (CCIS), Georgia Tech, Atlanta, GA, March 2019.
- [6] APS March meeting, Boston, MA, March 2019.
- [7] Tech Topology Conference, Georgia Tech, Atlanta, GA, December 2018.
- [8] The 11th Southeast Meeting on Soft Materials, Emory University, Atlanta, GA, May 2018.
- [9] Summer school on soft solids & complex fluids, University of Massachusetts, Amherst, MA, USA, May 2018.
- [10] A Symposium on Soft Matter Frontiers, Georgia Tech, Atlanta, GA, April 2018.
- [11] Industrial Partner's day and Exposition, STAMI, Georgia Tech, Atlanta, GA, October 2017.
- [12] Southeastern Undergraduate Mathematics Workshop, School of Mathematics, Georgia Tech, August 2017.
- [13] The 10th Southeast Meeting on Soft Materials, Georgia Tech, Atlanta, GA, May 2017.
- [14] Soft Matter Lunch and Posters, Soft Matter Incubator (SMI), STAMI, Georgia Tech, Atlanta, GA, April 2017.
- [15] APS march meeting, New Orleans, LA, March 2017.
- [16] Group on Soft Matter Physics (GSOFT) short course on fundamental concepts in Soft Matter Physics, APS march meeting, New Orleans, LA, March 2017.

²I attended some of the DSOFT, DPOLY and GSNP sessions virtually since the onsite conference was cancelled due to COVID-19 pandemic.

- [17] Soft matter research chat/coffee & cookies, SMI, STAMI, The School of Physics, Georgia Tech, Atlanta, GA, USA, 2017-2019.
- [18] Soft matter physics journal club, The School of Physics, Georgia Tech, Atlanta, GA, USA, 2017-2020.
- [19] Madhava nurture camp, Bhaskaracharya Pratishthana, Pune, Maharashtra, India, June 2011.

Research Experience

- [1] Title: A knot theoretic perspective of knitted fabrics (*Doctoral thesis*). Collaborators: Prof Elisabetta A. Matsumoto at the School of Physics in Georgia Tech. Computational & visualization tools: Mathematica, Regina, SnapPy, SageMath and Adobe Illustrator. Theoretical & analytical techniques: The theory of knots & links and Hyperbolic links.
- [2] Title: The QTZ-QZD family of surfaces: A triply-periodic family of chiral minimal surfaces from space group symmetries. Collaborators (*Doctoral thesis*): Prof Elisabetta A. Matsumoto, Prof Gerd Schröder-Turk at Murdoch University in Australia and Dr. Matthias Saba at the University of Fribourg in Switzerland. Computational & visualization tools: Mathematica, Surface Evolver, Maple and Adobe Illustrator. Theoretical & analytical techniques: The theory of minimal surfaces and the theory of two-dimensional algebraic curves and Riemann surfaces.
- [3] Title: Multivariable Alexander polynomials of links derived from knitted fabrics. Collaborators: Prof Elisabetta A. Matsumoto at the School of Physics in Georgia Tech and Prof Jennifer Hom in the School of Mathematics at Georgia Tech. Computational & visualization tools: Mathematica, SnapPy, SageMath and Adobe Illustrator. Theoretical & analytical techniques: The theory of knots & links.
- [4] Title: The steady-state behavior of synchronized coupled oscillators. Collaborators: Prof Kurt Wiesenfeld & Prof Michael Schatz at the School of Physics in Georgia Tech. Computational & visualization tools: Mathematica. Theoretical & analytical techniques: Non-linear dynamics, Bifurcation theory and Floquet theory.
- [5] Title: Classification of knots up to five crossings. Collaboration: a class team project. Computational & visualization tools: Python, Mathematica, sci-kit learn and Adobe Illustrator. Theoretical & analytical techniques: Knot theory, Supervised & unsupervised machine learning and Graph theory.
- [6] Title: Developing design templates for bone scaffolds based on triply-periodic minimal surfaces. Collaborators: Sebastien Callens at TU Delft in the Netherlands. Computational & visualization tools: Mathematica and Surface Evolver. Theoretical & analytical techniques: The theory of minimal surfaces and the theory of two-dimensional algebraic curves and Riemann surfaces.
- [7] Title: Ground states of zero temperature Kitaev-Heisenberg systems with periodic boundary conditions (*Masters thesis*). Collaborators: Prof Vikram Tripathi at the department of theoretical physics in Tata Institute of Fundamental Research, India. Computational & visualization tools: Mathematica, Fortran 90. Theoretical & analytical techniques: Statistical physics, Phase transitions & critical phenomena and Quantum mechanics of many-particle systems.

Professional Skills

- [1] Coding experience: Python, Fortran, Mathematica, Matlab, Maple.
- [2] Computational topology & geometry softwares: SnapPy, Regina, Surface Evolver.

- [3] Machine learning: Implementation and analysis (scikit-learn).
- [4] Visualization & design tools: Adobe Illustrator, Rhino.

Teaching Experience

- [1] Introduction to Electromagnetism: 2015 fall semester, 2016 spring semester, 2016 summer semester, 2016 fall semester, 2019 spring semester and 2020 summer semester (online teaching).
- [2] PHYS 3122-A – Electrostatics & Magnetostatics: 2017 fall semester, spring 2018 semester.
- [3] PHYS 3143-A & B – Quantum Mechanics I: 2018 fall semester, 2019 fall semester & 2020 spring semester.

Service to Profession

- [1] A reviewer for *The President's Undergraduate Research Award (PURA)* proposals during summer semester 2019, spring semester 2020 and summer semester 2020.
- [2] Co-organizer of *The Soft-Matter Coffee & Cookies/ Research Chat* spring semester 2019 and fall semester 2020.
- [3] A volunteer at the event, *A symposium on Soft Matter Frontiers* held at Georgia Tech from 04/18/18 to 04/20/18.

Community involvement/Service

I have served, several times, as a volunteer at the fundraising events hosted by *Asha for Education* – a non-profit organization to facilitate education and empowerment of young women in rural and developing parts of India.

Professional Memberships

- [1] Division of Soft Matter Physics (DSOFT), American Physical Society (APS).
- [2] Group on Statistical & Nonlinear Physics (GSNP), American Physical Society (APS).
- [3] Society for Industrial and Applied Mathematics (SIAM).

Miscellaneous

My doctoral thesis research topic was featured in the following science news articles:

- [1] Siobhan Roberts. *'Knitting Is Coding' and Yarn Is Programmable in This Physics Lab*, The New York Times^f (March 17, 2019).
- [2] *The science of knitting, unpicked*. Phys org, American Physical Society (APS)^g (March 6, 2019).
- [3] Eleanor Hook. *The Science of Knitting*, Physics Buzz^h (April 24, 2019).

References

- [1] Prof Elisabetta A. Matsumoto, Assistant Professor, The School of Physics, Georgia Tech, Atlanta. Email: sabetta@gatech.edu.
- [2] Prof Alberto Fernández-Nieves, Associate Professor, The School of Physics, Georgia Tech, Atlanta, GA-30332, USA. Email: alberto.fernandez@physics.gatech.edu.
- [3] Prof Kurt Wiesenfeld, Professor, The School of Physics, Georgia Tech, Atlanta, GA-30332, USA. Email: kurt.wiesenfeld@physics.gatech.edu.
- [4] Prof Jennifer Hom, Associate Professor, The School of Mathematics, Georgia Tech, Atlanta, GA-30332, USA. Email: jhom6@math.gatech.edu.
- [5] Prof Gerd Schröder-Turk, Associate Professor in Mathematics & Statistics, The School of Engineering & Information Technology, Murdoch University, Murdoch WA 6150, Australia. Email: gest73@gmail.com.